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NASA/MSFC FY-83 Atmospheric Research Review

ORIGINAL

Summary of a program review held at
Huntsville, Alabama
May 24-25, 1983

25th Anniversary
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NASA/MSFC FY-83 Atmospheric Research Review

Compiled by
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Marshall Space Flight Center, Alabama

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Huntsville, Alabama
May 24-25, 1983

National Aeronautics
and Space Administration

Scientific and Technical
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PREFACE

The principal purpose of this summary report is to provide those having major research activities sponsored by NASA on aviation safety research and assigned to MSFC's Atmospheric Sciences Division an opportunity to present their accomplishments and future plans. In addition, the review provides NASA Headquarters and MSFC Research Managers with a current status report and suggestions for future research to use in developing the program. To assist us in preparing the report, each investigator was requested to submit the technical aspects of his research efforts. The principal managers are Allan R. Tobiason, Aeronautical Systems Division, OAST, and Dennis W. Camp, Atmospheric Sciences Division, Systems Dynamics Laboratory, MSFC.

The technical aspects of the research efforts are stressed to provide the rationale for recommendations on the coming year's research. The organizers endeavored to make this report a review of the major aspects of the sponsored research activities relative to the NASA program aims. The report was planned to permit the maximum exchange of information.

It was recognized that the scopes of individual research efforts comprise a wide range. Some are very modest or have been under way for only a short period of time, whereas others involve several years of activity. However, the opportunity to learn what each investigator is doing and to develop the team relationship necessary for a meaningful research program is considered most important. It is toward this goal that this summary report has been developed.

Recipients of this document are encouraged to communicate directly with the respective Principal Investigators regarding scientific and technical matters or questions they might have on the research efforts. Any suggestions or recommendations concerning the program will be welcomed.

William W. Vaughan, Chief
Atmospheric Sciences Division
Systems Dynamics Laboratory
NASA/Marshall Space Flight Center

INTRODUCTION

The Aviation Safety-Atmospheric Processes program at the NASA/Marshall Space Flight Center has served a vital function for several years. It has been one of the programs used for determining the effects of the atmosphere on aeronautical systems. The results obtained have been useful not only to aeronautical systems but also to space systems. The benefit to the space effort is easier to comprehend now than it was a few years ago. The reason for this is that the Space Shuttle returns to Earth as an unpowered aircraft, operating very much like an airplane. Thus, these aeronautical research focused efforts have direct value to NASA's aerospace vehicles.

There are three main objectives to this program as a part of the overall NASA Office of Aeronautical and Space Technology's activities, namely:

1. To define, investigate, and model atmospheric conditions having adverse effects on aeronautical operations relative to safety and efficiency.

2. To conduct research relative to the development of techniques and procedures for enhancing safe and efficient operations of aeronautical systems.

3. To develop and/or improve meteorological instrumentation and methods as needed to accomplish the first two objectives.

To accomplish these objectives, a well-rounded program involving data acquisition, data analysis, simulation studies, analytical efforts, and theoretical investigations is being conducted. As a result of conducting the program, eight tasks have been identified for emphasis in FY-83. These tasks are:

1. The correlation of lateral and longitudinal gusts as measured across the span of an airfoil. The results of this effort will be used to develop models of wind gusts and gust gradients which can be used in aeronautical design, flight simulation, and flight operations.

2. The acquisition, development, and summarization of basic information (both experimental and theoretical) on atmospheric dynamics processes for direct application to safe and efficient operations of aeronautical systems.

3. Investigate various techniques for the dispersal of warm fog.

4. Study the electrical properties of thunderstorms in order to better identify spatial and temporal characteristics that can be used in both hazard identification/avoidance applications and to improve our fundamental understanding of cloud electrification processes.

5. The analysis of data obtained by use of Doppler Lidar Systems for use relative to Aeronautical Systems.

6. There are three aspects to this task, namely:

   a. To conduct an Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems.

   b. To conduct an interagency meteorology R&T retreat.

c. To publish a bibliography of aviation meteorology programs.

7. Develop new and/or to improve present meteorological instrumentation in support of the other tasks of this program.

8. The participation in an interagency wind shear research effort relative to improving the safe operation of aeronautical systems.

The information presented in the following portion of this paper, gives a status report on some aspects of the above stated tasks. Additional information relative to this program can be obtained by contacting Dennis W. Camp (Atmospheric Sciences Division of the Marshall Space Flight Center). Also the research investigators identified on each task are available and will welcome inquiries concerning their technical activities reported herein.

TITLE: B-57B Gust Gradient Program

RESEARCH INVESTIGATORS: Warren Campbell
and
Dennis Camp
ED42/Atmospheric Sciences Division
Marshall Space Flight Center, AL 35812

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

Analysis of data obtained from the Joint Airport Weather Studies (JAWS) Flights 6 and 7 is underway. Data from Flight 7 indicate that the B-57B encountered the upper portion of an outflow feature (microburst) at an altitude of 400 meters above ground level. Horizontal wind vector plots along the flight path have provided clues concerning the meteorological setting of the flights. In addition to suspected outflow features, wavelike variations of the horizontal wind vectors were observed.

Statistical studies of gust gradients were undertaken with the goal of fitting probability density functions to the data. As expected, the density functions were highly non-Gaussian. Spectral analyses are proceeding and several spectral models for the gust gradient data are being investigated.

FOCUS OF CURRENT RESEARCH ACTIVITIES:

The ultimate goal of the Gust Gradient Program is to provide models useful for aeronautical vehicle design and flight simulation. Recently, a new method of atmospheric turbulence simulation was proposed, which provides a framework for utilizing JAWS data for flight simulation. The technique provides a framework for using the JAWS data and is particularly suited for Doppler radar data.

Additional efforts consist of preparation for data flights at MSFC in conjunction with the Eight Tower Array and the NASA Lidar, and for flights at the National Severe Storm Laboratory (NSSL) at Norman, Oklahoma. The NSSL flights will be in conjunction with the Spring Storm Observations Program.

PLANS FOR FY-84:

Development of the mathematical details of the 4-D wind simulation model are being completed. During the remainder of FY-83 the mathematics and a demonstration computer code will be developed and documented.

Spectral analysis of the gust gradient data will continue with analysis of additional JAWS data, and some data obtained at the NASA Dryden Flight Research Facility.

Correlations of flight data with JAWS radar tapes are planned. Some tapes have already been received from the National Center for Atmospheric Research for use in these correlations.

Additional data flights are planned in May at MSFC and at NSSL. The Gust Gradient team will go to each of these locations for the tests.

RECOMMENDATIONS FOR NEW RESEARCH:

The 4-D wind model requires certain inputs from the JAWS data. The model may require a slightly different slant on the JAWS data analysis. Some effort should be made to determine the most efficient way to interface the model with the JAWS data analysis.

Gust gradient data can provide extremely useful inputs to the model. The flight data should be analyzed to provide these inputs. The required type of analysis has been reported in the literature and is available at minimal cost using slight modifications of currently available computer codes.

LIST OF PUBLICATIONS PREPARED SINCE JUNE 1982:

1. Campbell, Warren and Walter Frost: "NASA's B-57B Gust Gradient Program," presented at the NASA/MSFC FY-82 Atmospheric Processes Research Review, October 19-21, 1982.

2. Campbell, Warren: "A Cursory Glance at Results from NASA's B-57B Gust Gradient Program," presented at the Sixth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems, October 1982.

3. Camp, Dennis, Warren Campbell, Walter Frost, Harold Murrow, and Weneth Painter: "NASA's B-57B Gust Gradient Program," Presented at the AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, January 1983 and accepted for publication in Journal of Aircraft.

4. Campbell, Warren, Dennis Camp and Walter Frost: "An Analysis of Spanwise Gust Gradient Data," to be presented at the AMS/AIAA 9th Conference on Aero-Space and Aeronautical Meteorology at Omaha, Nebraska, June 1983.

5. Frost, Walter, and Dennis Camp and Warren Campbell: "Spanwise Turbulence Modeling," to be presented at the AMS/AIAA 9th Conference on Aerospace and Aeronautical Meteorology at Omaha, Nebraska, June 1983.

6. Campbell, Warren: "A Conceptual Framework for Using Joint Airport Weather Studies (JAWS) Data for Flight Simulation," submitted as a NASA Technical Publication, March 1983.

TITLE: The Joint Airport Weather Studies (JAWS) Project

RESEARCH INVESTIGATORS: John McCarthy
and
James Wilson
Field Observing Facility
National Center for Atmospheric Research
Boulder, CO 80307

Dr. T. Theodore Fujita
Dept. of Geophysical Sciences
University of Chicago
Chicago, IL 60637

SIGNIFICANT ACCOMPLISHMENT TO DATE IN FY-83:

The Joint Airport Weather Studies (JAWS) Project, formed in 1980, conducted a major field investigation during the summer of 1982 (15 May to 13 August, inclusive) in and around Denver, Colorado. The project is jointly conducted by the National Center for Atmospheric Research (NCAR) and the University of Chicago. The principal objective of JAWS was to examine convectively driven downdrafts and resulting outflows near the earth's surface known as microbursts, a term coined by Dr. Fujita of the University of Chicago, Microbursts can be lethal for jet aircraft on takeoff or landing because of the extreme magnitude of the flows.

The JAWS effort has concentrated on three aspects of microburst-induced, low-level wind shear: basic scientific investigation of microburst origins, lifecycles, and velocity structures; various aspects of aircraft performance, including numerical models, manned flight simulators, instrumented research aircraft response, and operational air carrier performance; and low-level wind shear detection and warning using surface sensing, airborne systems, and radar sensing.

The data collection phase was truly extraordinary. Of 91 possible operational days, 75 had convective weather on which at least one of 38 pre-planned JAWS experiments could be conducted. We expected to observe 10 to 12 microbursts with more than one Doppler radar, but saw 87! We collected many data sets not only on wind shear events but on mesocyclones, tornadoes, gust fronts, hailstorms, and flash floods. Our collection also included a broad data set on operational uses of Doppler weather radar, which will be used to support the Next Generation Radar (NEXRAD) Doppler development and procurement in the United States.

During FY-83, we prepared a 276 page report "The JAWS Project, Operations Summary 1982," which was distributed to sponsoring agencies and interested scientists. The report contains an up-to-date summary of the available JAWS data, instruction on how to obtain them, and a daily summary of data collection. We describe the meteorology of each day and the weather event highlights, and discuss each significant experiment conducted. For each operational day, a table shows the operating hours of each observing system (i.e., radars, lidars, aircraft, surface network, etc.) Finally, on days of significant JAWS weather, a map of the network showing the event location is included. Table 1 indicates the complete scientist, institution and sensor involvement in the JAWS field experiment. Complete details can be obtained first from the Operations Summary or from the individuals listed as appropriate in the Table 1.

While the data set was extraordinary in its extent and number of significant weather events, the summary, although not exhaustive, identifies events of principal interest to the many JAWS objectives.

CURRENT FOCUS OF RESEARCH WORK:

At present, we are concentrating on an evaluation of the low-level wind shear alert system (LLWSAS), on preparation of four dimensional multiple Doppler radar fields on the capability of a single Doppler radar to identify microburst and shear events, and development with assistance from the Federal Aviation Administration of a wind shear information film.

We have just compiled a prioritized list of the most interesting microburst cases for multiple Doppler editing and analysis using an over-determined dual Doppler analysis (ODDAN) program which is currently being made user friendly.

Work by subcontractor (FWG Associates, Inc.) is progressing on the development of a six-degree of freedom aircraft performance model. Under a subcontract with NOAA, Al Bedard has constructed programs to analyze and display low-level wind shear alert system (LLWSAS) and Portable Automated Mesonet (PAM) data and to produce plots combining PAM/LLWSAS data showing wind vectors sequentially for selected case studies.

Working with scientists from NASA and NOAA, JAWS personnel are modifying computer programs to help prepare dual-lidar analysis comparisons.

NCAR Doppler radar data are being used to support the NASA's B-57B Gust Gradient effort to identify both longitudinal and internal gust components of turbulence and wind shear.

We are preparing nine papers for the 21st Conference on Radar Meteorology: (1) "Dynamic Interpretation of Notches, WERS, and Mesocyclones Simulated in a Numerical Cloud Model"; (2) "Analysis of Bias Measurements in Relation to Small-Scale Meteorological Events"; (3) "The Structure of a Microburst: As Observed by Ground-Based and Airborne Doppler Radar"; (4) "Aircraft and Doppler Air Motion Comparisons in a JAWS Microburst"; (5) "Weighted Least Squares Methods for Multiple Doppler Radar Analysis"; (6) "Microburst Wind Structure Using Doppler Radar, PAM and LLWSAS Data"; (7) "JAWS Data Collection, Analysis Highlights, and Microbursts Statistics"; (8) "Aircraft Performance in a JAWS Microburst"; and (9) "Evaluation of Doppler Radar for Airport Wind Shear Detection."

PLANS FOR FY-84 & 85:

A very brief outline of the complete complement of tasks being addressed in FY-83 & 84 is given in Table 2. More details are available by calling the JAWS Project Office on (303) 497-0651.

New NASA research objectives for FY-84 & 85 that should be addressed focus around manned flight simulation theory and practice in wind shear conditions. The current work of Frost (FWG Associates) and at NASA Langley Research Center, utilizing high resolution JAWS wind shear data to better understand aircraft performance, leads to the following projected tasks for FY-84 & 85:

(1) Research and training simulator frequency response to wind shear input visuals.

(2) A careful study of simulator equations of motion with regard to wind shear.

(3) Extensive communication with simulator technology experts regarding the findings of (1) and (2).

These tasks need to be refined and examined, not only through JAWS and NASA research, but through a close association with airborne and flight simulator manufacturers.

RECENT PUBLICATIONS:

"The NCAR Research Aviation Facility Fleet Workshop, 18-19 February 1982, Boulder, Colorado," Bull. Amer. Meteor. Soc., to be published in May 1983 by P. H. Hildebrand and J. McCarthy.

"Low-Level Wind Shear Detection and Warning – A Systems Update," AIAA 21st Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, Nevada, by J. McCarthy and J. W. Wilson.

"Applications of Doppler Radar to Aviation Operations – JAWS Experiences," AIAA 21st Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, Nevada by J. McCarthy and J. W. Wilson.

"The Joint Airport Weather Studies," 17th Annual Southern Methodist University Air Law Symposium, March 3-5, 1983, Dallas, Texas by J. McCarthy.

"The JAWS Project Operations Summary 1983," printed in February 1983 by the National Center for Atmospheric Research, limited distribution, copies available upon request.

TABLE 1. ORGANIZATIONS AND EQUIPMENT IN JAWS

Organizations Participating in JAWS	Contact for Data	Sensors/Equipment	Comments
Federal Government			
National Science Foundation			
o National Center for Atmospheric Research			
– Convective Storms Division	Ed Zipser Pete Johnson	NCAR Sabreliner Multiple Aircraft Positioning System	Mesoscale Analysis Calculates aircraft location using interferometry
– Field Observing Facility	Phyllis O'Rourke	Portable Automated Mesonet (PAM) Doppler Radars	27 Stations two 5-cm and one 10-cm
Federal Aviation Administration	Marty Natchipolsky	Low-level Wind Shear Alert System (LLWSAS)	Funding agency
National Aeronautics & Space Administration			Funding agency
o Marshall Space Flight Center (MSFC)	Dennis Camp Warren Campbell George Fichtl	B-57B Aircraft, CO_2 Doppler Lidar	
o Langley Air Research Center		B-57B Aircraft, Manual Flight Simulator	
o Dryden Flight Research Facility		B-57B Aircraft	
National Oceanic & Atmospheric Administration			
o Program for Regional Observing & Forecasting Services (PROFS)	Ron Valdez Ron Valdez Ron Valdez Ron Valdez Ron Alberty	Mesoscale Surface Network AFOS Products Limon & Cheyenne Radars Lightning Detection Array Satellite Data	

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TABLE 1. (Concluded)

Organizations Participating in JAWS	Contact for Data	Sensors/Equipment	Comments
o Wave Propagation Laboratory (WPL)	Freeman Hall	CO_2 Doppler Lidar	
	Al Bedard	LLWSAS Analysis	
	Al Bedard	Pressure Jump System Data Collection and Analysis	
	John Gaynor	Boulder Atmospheric Observatory Tower	
	Ron Valdez	Atmospheric Profiler	
o Weather Research Program	Fernando Caracena	Microburst Forecasting/Nowcasting Techniques	
o National Hurricane & Experimental Meteorological Laboratory/NCAR	Dave Jorgensen Peter Hildebrand	NOAA P-3 Aircraft/Airborne Doppler	Joint NOAA/NCAR Experiment
o National Weather Service	Phyllis O'Rourke	Rawinsonde (4 daily, 2 regular, 2 special)	
o PROFS/JAWS/CSD	Mary McCoy	Cooperative Storm Intercept Group	Photograph & verify weather hazards identified by Doppler radar
Transportation Systems Center (Dept. of Transportation)	Lloyd Stevenson	Air Traffic Control Data	Study effects of weather on terminal air traffic
Universities and Colleges			
University of Chicago	T. Theodore Fujita	Whole Sky Camera	Photographed from CP-2
University of Wyoming	Al Rodi	King Air Aircraft/Microphysics Instrumentation	Aircraft leased to NCAR
Dartmouth College	Robert Crane		Test Crane cell tracking and turbulence algorithms
Foreign			
United Kingdom			
o Royal Aircraft Establishment	Alan Woodfield	Hawker-Siddeley 125 Aircraft	
o Royal Signals and Radar Establishment	Michael Vaughan	Airborne CO_2 Doppler Lidar	

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TABLE 2. A VERY BRIEF SUMMARY OF TASKS BEING ADDRESSED AT NCAR BY THE JAWS PROJECT

Physical Mechanisms

1. Microburst Climatology
2. Microphysical Interactions with Microburst Negative Buoyancy
3. Microburst Precipitation Physics/ Dynamics Feedback
4. Microburst Cloud Modeling (Klemp)
5. Boundary Layer Interactions in Microburst Situations

Definitions & Statistics

1. Variability of Microbursts in Time & Space (Radar and PAM)
2. Microburst/Downburst Scales
3. Terminology/Definitions — Wet vs. Dry Microbursts

Techniques

1. Kinematic Fields in Microburst Analysis
2. Complete Multiple Doppler Synthesis Program
3. Sensor Intercomparison
4. 3 Airborne/Surface Doppler Synthesis

Aircraft Performance

1. Flight Simulation Using Multiple Doppler Data
2. Doppler Derived Turbulence
3. Aircraft Performance in Microbursts
4. Penetration Techniques for Microbursts
5. Flight Simulator Fidelity in Microbursts
6. B-57B Correlation Synthesis
7. Heavy Rain Aircraft Performance
8. Rotocraft Performance in Microbursts

Detection and Warning

1. Redesign of LLWSAS
2. Radar Siting for Terminal Doppler Radar
3. Airport-Located Doppler Radar Microburst Detection Techniques
4. Airborne Detection & Warning Synthesis
5. Observational Precursors for Microbursts
6. Avoidance Techniques (Pilot) for Microbursts
7. Evaluation of Detection & Warning Concepts
8. Evolution of Crane Cell Tracking and Turbulence Algorithms
9. Microburst Pilot Forecast Advisories
10. Sampling Theory/Detection Using Surface Arrays
11. Lidar Surface Detection & Warning
12. IR Radiometer Detection of Microbursts

Miscellaneous

1. Prioritization of Cases
2. Wind Shear Information Film for Pilots
3. Analysis of Meteorological Features Affecting Formation of Microbursts
4. Terminal Air Traffic (TSC) Impacts Due to Convective Storms
5. Documentation

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TITLE: Development of an Operational Specific CAT Risk (SCATR) Index

RESEARCH INVESTIGATORS: John L. Keller
Research Institute JPC-201
Dayton, Ohio 45469

Patrick A. Haines
Research Institute JPC-201
University of Dayton
Dayton, Ohio 45469

James K. Luers
Research Institute JPC-201
University of Dayton
Dayton, Ohio 45469

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

The original formulations of Roach (1970) and Oard (1974) for the calculation of CAT potential from synoptic scale data have been extended. An index which gives a measure of the specific risk of encountering CAT – the SCATR index – has been defined. This index takes into account both the locally and advected contributions to the energy necessary for CAT. The advected contribution is associated with the role of atmospheric gravity waves (AGWs).

The SCATR index has been calculated for a number of cases where documented encounters with CAT occurred. Of particular interest were those made for cases involving severe CAT. The results for the two severe CAT cases run were quite impressive and have begun to elicit considerable interest from operational aviation meteorologists. The results of these severe CAT encounters, the United accident of 0125Z 4 April 1981 over Hannibal, MO and the Kennedy-Shapiro field study of 11 and 12 April 1978, will be presented at the Ninth Conference on Aerospace and Aeronautical Meteorology.

FOCUS OF CURRENT RESEARCH:

Currently research is focusing on detailed analysis of the results obtained to this point and the pursuit of information on other documented severe CAT encounters. The point of the analyses is to develop an understanding of the dynamics associated with severe CAT outbreaks. The other CAT encounters are being sought in order to test the SCATR technique for different severe CAT producing situations. Several other severe CAT encounters have been uncovered in the course of discussions with airline meteorologists. The data necessary to calculate SCATR indices for these particular encounters is currently being gathered.

PLANS FOR FY-84:

- o Calculation and analysis of SCATR indices for several other severe CAT encounters of particular interest to the commercial airline meteorologists mentioned above.
- o Arrange for access to NMC analysis data base and development of interfacing software for obtaining daily near real-time conventional meteorological data.
- o Calculate SCATR index fields using the above conventional data near real-time.

- Arrange to obtain timely PIREPS of CAT.

- Calibrate SCATR index using the appropriate PIREPS over a six to nine month period.

- Thorough validation of performance using the CAT PIREPS and calibrated SCATR index/ completed proof of concept for operational systems.

RECOMMENDATIONS FOR NEW RESEARCH:

- Parameterization for significant, large scale-terrain.

- Adapt SCATR algorithms for use of Limited-Fine-Mesh (LFM) forecast products for SCATR index forecast.

- Performance of SCATR formulation using mesoscale data set (e.g., AVE/SESAME).

LIST OF PUBLICATIONS PREPARED SINCE JUNE 1982:

- Keller, J. L., 1982: Detection of Clear Air Turbulence Using a Diagnostic Richardson Number Tendency Formulation. J. Aircraft, 19(11), 904-908.

- Keller, J. L., 1983: CAT Detection and Forecasting Using Operational NMC Analysis Data. Proc. Ninth Conf. Aerospace and Aeronau. Met., American Meteorological Society, Omaha, Nebraska.

TITLE: Workshop – Electrostatic Fog Dispersal

PROJECT DIRECTOR: Dr. M. H. Davis
USRA
P.O. Box 3006
Boulder, CO 80307

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

On February 1-2, 1983, USRA conducted a workshop on electrostatic fog dispersal methods at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. The objectives of the Workshop were to review the current status of ground-based methods for dispersal of warm fog at airports through injection of charged particles; to assess the scientific merits and basis of the system under study by FWG Associates, and to discuss the steps that should be taken to demonstrate the viability of the concept.

The Workshop concluded that there is not enough information at present to allow an adequate assessment of the charged particle jet method. A report was prepared by USRA and submitted to NASA/MSFC that summarizes the proposed technique, and gives detailed recommendations on the logical steps that should be taken to obtain the information needed to allow the system to be evaluated. The report concluded with statements prepared by Workshop participants.

PARTICIPANTS IN THE WORKSHOP:

Prof. Marx Brook	Mr. Albert Brown
Dr. William Cotton	Dr. M. H. Davis
Dr. Meredith Gourdine	Dr. James Jiusto
Mr. Warren Kocmond	Mr. Bruce A. Kunkel
Dr. John Latham	Dr. Hendricus Loos
Dr. John E. Minardi	Mr. Sabert Oglesby
Mr. Byron Phillips	Dr. Lothar Ruhnke
Dr. William T. Scott	Dr. John Wyngaard

Presentation by: Dr. Walter Frost
NASA Representatives: Mr. Dennis Camp, Dr. Vernon W. Keller
Airline Observers: Mr. C. L. Chandler, Mr. John Pappas
FAA Observer: Mr. John W. Hinkelman, Jr.

The USRA report will form the basis for a NASA/MSFC Workshop Report. A summary paper is planned for submission to a research journal.

TITLE: Warm Fog Dispersal

RESEARCH INVESTIGATORS: Walter Frost
K. H. Huang
FWG Associates, Inc.
Tullahoma, Tennessee 37388

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

The charged particle generator was further tested after some design modification. The generator performance was measured with additional instrumentation and found to confirm previous measurements. Plans for a field testing were then developed.

The overall status of the program and the field test plans were presented to a group of atmospheric scientists and electrostatic experts at the NASA/MSFC sponsored USRA Workshop on Electrostatic Fog Dispersal at NCAR, Boulder, Colorado discussed in previous sections. The recommendations from this workshop are being evaluated as to whether NASA should proceed with the field test or whether further theoretical research on the phenomenon of electrostatic fog dispersal and additional development of the charged particle generator should be carried-out.

FOCUS OF CURRENT RESEARCH ACTIVITIES:

Information obtained from the USRA Workshop clearly identified three physical mechanisms that could possibly influence the fog dispersal process, which heretofore have not been considered, and which may provide additional insight to the direction of further fog dispersal work.

These mechanisms are: (1) the effect of corona discharge on the electric field strength at the surface, (2) the influx of fog into the cleared volume by turbulent diffusion, and (3) the increase in supersaturation as liquid water is removed, activating haze particles, and thus generating more fog. Plans are being formulated to investigate these mechanisms.

The limited electrostatic fog dispersal field studies carried out at the Panama Canal reported measured electric field values of 10^5 volts/meter at ground level. It was the general concensus of the committee, however, that these fields were one to two orders of magnitude high because of corona discharge at the surface. Interestingly enough, no one could provide a verifiable magnitude of the electric field possible at the surface. FWG Associates has pursued this and found that the agricultural insecticide community, who sprays with charged droplets, has made rough measures of the maximum surface electric field that can be sustained without excessive corona discharge. This new information should be incorporated into the final report, and a number of design values recomputed with this new information. An order of magnitude reduction of the electric field at the ground, if real, will drastically change the conclusions of the overall studies and should be verified before publishing the final document.

A second physical effect identified at the workshop was that the turbulent diffusion of fog into the cleared volume element could be considerably larger than predicted. The premise at the workshop was that the fog would diffuse back into a volume element which is fixed in space. This is not exactly correct, since the

volume element to be cleared drifts with the flow, and thus a Lagrangian rather than an Eulerian turbulence must be considered. However, based on the strong committee recommendation, it is necessary to recheck the magnitude of fog influx due to turbulence.

Finally, a phenomenon was identified which has not been considered in prior analyses or even discussed in the vast literature relative to electrostatic fog dispersal techniques. This is that by removing liquid droplets from the volume element, the supersaturation will be raised sufficiently to activate previously unactivated haze particles. These then form cloud droplets bringing the fog droplet population back to near original levels. The physically possible growth rates of droplet density should be analyzed at least on an order of magnitude basis to assure this effect is not significant.

PLANS FOR FY-84:

Analyze the order of magnitude effect of the three physical mechanisms identified at the fog dispersal workshop which affect the electrostatic fog dispersal process:

a) The effect of corona discharge on the maximum electric field values achievable at ground level.

b) The influx of fog into the cleared volume element due to turbulence.

c) The growth of new fog droplets due to increasing supersaturation by migration of existing fog droplets out of the volume element.

Respond to the workshop finding relative to either carrying-out additional basic research, proceeding with the field test or beginning to look at new modern technology relative to penetrating fog (such as the "Majic Window Concept") rather than dispersion.

LIST OF PUBLICATIONS:

1. Walter Frost and Kao-Hyah Huang: "Test Results of Modified Electrical Charged Particle Generator for Application to Fog Dispersal," NASA CR-3674; February, 1983.

2. Walter Frost: "Preliminary Test Results of Electrical Charged Particle Generator for Application to Fog Dispersal," NASA CR-3654, November, 1982.

TITLE: Low-Level Gust Gradient Program and Aviation Workshop Effort

RESEARCH INVESTIGATORS: Walter Frost
Ming-Chang Lin
Linda W. Hersham
University of Tennessee Space Institute
Tullahoma, Tennessee 37388

Dennis W. Camp
Warren Campbell
ED42/Atmospheric Sciences Division
NASA/MSFC
MSFC, AL 35812

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

The Proceedings of the Workshop on Meteorological and Environmental Inputs to Aviation Systems, hosted by the University of Tennessee Space Institute (UTSI), October 26-28, 1982, have been prepared for publication. The Proceedings have been submitted to FAA and will be distributed by August. Also, the proceedings of a one-day workshop devoted specifically to wind shear and hosted during the same time frame have been prepared and distributed as a NASA Contractor Report.

Plans for the 1983 workshop are proceeding extremely well. The workshop theme has been established, the committee topics identified, and all ten (10) committee chairmen contacted have agreed to accept their respective assignments. Additional logistics for the workshop are being carried out. The 1983 workshop is scheduled for October 26-28, 1983.

Data gathered with the B-57B during the JAWS Project in Denver, Colorado, havebeen analyzed. All runs for Flight 6 on July 16, 1982, have been analyzed. Spectra, cross-spectra and probability distributions have been computed for each run. Also, Runs 10-14 of Flight 7 on July 15, 1982, have been analyzed in similar detail.

The extensive tower array data available to provide ground truth have been thoroughly analyzed. A final report summarizing all of these data as it pertains to gust gradients on airfoils and over aircraft near ground level has been documented and submitted for final review to the NASA Contract Monitor.

FOCUS OF CURRENT RESEARCH ACTIVITIES:

The specific goals of the gust gradient aspect of the program are to analyze the data and to develop new theoretical concepts and analytical or empirical models of the turbulence statistics that are important to aerospace vehicle design and flight simulation. The data from the tower array and the preliminary data from the Gust Gradient Program illustrate that new models of cross-spectra require development. The major emphasis of the Gust Gradient Program was to understand the variation of wind across an airfoil and how it affects factors such as bending moments, roll, yaw, etc. Thus, the cross-spectra terms are extremely important in such analysis. Mathematical expressions for gust gradient, that can be used as aircraft design criteria, will be developed. Analysis of the data gathered at MSFC in conjunction with the Eight-Tower Array and at the National Severe Storms Lab (NSSL) at Norman, Oklahoma, will be carried out. The NSSL flights were in conjunction with the Spring Storm Observation Program.

The 1983 workshop will be hosted and the proceedings prepared for publication.

PLANS FOR FY-84:

Continued analysis of the data from the JAWS Project, NASA Dryden, and NSSL flights will be carried out. From these data, mathematical models of the cross-spectra, and other statistical parameters will be developed that can be utilized for aircraft design criteria.

The data will be documented and distributed in the form of NASA Contractor Reports for use by the entire aviation community.

The Gust Gradient data will be analyzed to provide inputs to model being developed for simulation purposes.

LIST OF PUBLICATIONS PREPARED SINCE JUNE 1982:

1. Frost, Walter and Ming-Chang Lin: "Statistical Analysis of Turbulence Data from the NASA Marshall Space Flight Center Atmospheric Boundary Layer Tower Array Facility." Final Report prepared under NASA Contract No. NAS8-34627, May 1983.

2. Frost, Walter and Dennis Camp: "Proceedings: Sixth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems" NASA CP-2274, October 26-28, 1982.

3. Enders, John H., William W. Melvin, Walter Frost and Dennis Camp: "Summary Proceedings of a Wind Shear Workshop," University of Tennessee Space Institute, Tullahoma, Tennessee, October 25, 1982.

4. Akkari, Safwan H., and Walter Frost: "Analysis of Vibration Induced Error in Turbulence Velocity Measurements from an Aircraft Wing Tip Boom," NASA Contractor Report 3571, June 1982.

TITLE: Feasibility Study of a Procedure to Detect and Warn of Low-Level Wind Shear

RESEARCH INVESTIGATORS: Walter Frost
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SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

The results of the previous three years of contract efforts relative to understanding and modelling wind shear and detecting wind shear with radar were summarized into a final report. Because much of this effort had culminated into the JAWS program and 1982 and 1983 funds were directed toward JAWS, the effort under the NAS8-33458 contract was directed toward monitoring the JAWS field program and toward providing guidance and technical support in terms of the aircraft performance.

FOCUS OF CURRENT RESEARCH:

The wind shear program is now directed toward investigating the effects of wind shear on aerodynamic performance. Combining the JAWS wind shear data with the B-57B gust gradient data, the transient scales of motion involved in wind shear aircraft accidents or mishaps are being identified. The effect of variable winds having these time scales on the aerodynamic coefficients of moist airfoils has not been fully investigated. Transient and spatial variation of flow over the airfoil may cause premature stall or hysteresis effects which significantly impact the lift and drag (i.e., aerodynamic coefficients). Analysis of airfoil performance subject to 4-D variable flows will be carried out.

PLANS FOR FY-84:

Determine the effect of a highly varying velocity gradient on the drag coefficient (C_D), lift coefficient (C_L), moment coefficient (C_M), and pressure coefficient (C_p) for airfoil configurations of generic types of aircraft.

Repeat the Frost and Hutto (1974) analytical study on the influence of wind shear on aerodynamic lift and drag and on roll and yaw moments of typical aircraft using experimental gust gradient data obtained in the NASA B-57B Gust Gradient Program and the JAWS project.

Study the effect of lateral and longitudinal gust gradients on flow separation and and reattachment (separation bubble) on the wing of typical aircraft and develop the necessary theory and governing equations to proceed with computer program development.

LIST OF PUBLICATIONS:

1. Walter Frost: "Flight in Low-level Wind Shear," NASA CR3678; March, 1983.

2. Walter Frost: "Low-Level Wind Variability Effects on Aircraft Performance," presented to National Academic of Science Committee on Wind Shear.

3. Walter Frost and Enice Hutto: "The Influence of Wind Shear on Aerodynamic Coefficients," Proceedings of the Sixth Conference on Aerospace and Aeronautical Meteorology of the American Meteorological Society; November 12-15, 1974; El Paso, Texas; Am. Met. Soc., Boston, Mass.

TITLE: Doppler Lidar Signal and Turbulence Study

RESEARCH INVESTIGATORS: Walter Frost
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SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

Comparison of the second moments of the Doppler lidar signal with aircraft- and tower-measured parameters is being carried out under NASA Contract NAS8-35185 which began in May 1983.

Lidar binary data tapes have been successfully converted to ASCII Code on the VAX 11/780. A trial tape was received from Dan Fitzjarrald for Flight No. 19, July 27, 1981, Central Valley, California. These data were used to develop the computer programs for analyzing data from the MSFC field test. Raw lidar amplitude along the first 50 forward and backward beams of Run No. 2, respectively, have been plotted. Plotting techniques for the same beams except with the amplitude thresholded and range corrected have been developed. Plotting routines for the corresponding lidar width of the first 50 forward and backward beams have also been established. The relationship between raw lidar amplitude and lidar width has been examined. The lidar width is roughly constant for lidar amplitudes less than 120 dB.

A field test with the NASA/MSFC ground-based Doppler lidar, the instrumented NASA B-57B gust gradient aircraft, and the NASA/MSFC eight-tower array was carried out. The data tape for the lidar has been received and read. The aircraft data and tower data are being digitized and converted to engineering units.

Velocities computed sequentially along each of the lidar beams beginning at 16:40:00, May 12, 1983 have been plotted for Run No. 1. For Run No. 1, the lidar was set at 6 deg elevation and 0 deg azimuth angle. The airplane flew approach paths near the lidar beams.

FOCUS OF CURRENT RESEARCH:

Comparison of the lidar second moment results with the B-57B and tower-measured data will be made when these data are available.

Factors which cause spectrum broadening will be analyzed theoretically, thus additional insight into the correlation which may be expected between the lidar second moment and the turbulence parameter measured with other instrumentation will be provided.

PLANS FOR FY-84:

Develop a correlation between turbulence intensities and the Doppler width (second moment) and test the correlation with data gathered during the 1983 experimental field program using the NASA/MSFC ground-based Doppler lidar, the instrumented NASA B-57B gust gradient aircraft, and the NASA/MSFC eight-tower array.

Before developing the correlation with the second moment, it will be necessary to determine the effect of the signal intensity (zeroth moment) on the measurement of the Doppler width by the DLS signal processor.

Analytically investigate the relationship between the turbulent length scale and the second moment of the Doppler lidar signal.

TITLE: Low-Level Flow Conditions Hazardous to Aircraft

RESEARCH INVESTIGATORS: Margaret B. Alexander
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ED42/Atmospheric Sciences Division
NASA/MSFC
Marshall Space Flight Center, AL 35812

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-83:

Low-level flow conditions known to be hazardous to aircraft during takeoff/climbout and approach/landing operations are turbulence, wind shear, and vertical motion. These conditions can and frequently do occur separately and in combinations.

The identification and selection have been completed of representative data cases to determine magnitude, frequency, duration, and simultaneity of occurrence of turbulence (gustiness and gust factor), wind shear (speed and direction), and vertical motion (updraft and downdraft), along with temperature inversions.

New representations of temporal and spatial variations in the atmospheric boundary layer have been developed.

Efforts continue relative to low-level flow conditions where published results imply strong vertical shear with virtually no horizontal shear and where order-of-magnitude analyses of the equations of motion for an aircraft illustrates that low velues of horizontal shear (along the flight path) are much more hazardous than larger values of vertical wind shear (altitude).

Other areas where efforts are continuing are relative to:

(1) research to resolve the magnitude of maximum downdrafts and the heights at which they occur, and

(2) measurements of low-level wind shear and turbulence in stable flows as typically found during the nighttime.

FOCUS OF CURRENT RESEARCH ACTIVITIES:

Recognition of hazardous conditions during the critical landing and takeoff phases of flight has mandated studies to detect and measure these conditions. But relatively little high-resolution data from meteorological towers and/or aircraft are available to determine realistic values. The 150- and 18-meter towers at the Ground Winds Tower Facility located midway between Launch Complex 39B and the Space Shuttle runway at Kennedy Space Center, Florida, are unique sources of high-resolution wind and temperature profile measurements to be fully exploited.

World Meteorological Organization recommended practices will be adhered to when possible, viz., for aviation climatology: wind-averaging periods not exceed 10 minutes, gust-measuring periods be at least 5 seconds, temperature measurements be at 1.25 to 2 meters above ground level, etc.

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PLANS FOR FY-84:

Statistical summaries and descriptions of low-level flow conditions from data recorded at the KSC Ground Winds Tower Facility will be prepared. These summaries and descriptions will be used for information, comparisons, and flight simulation purposes. It is expected that these statistics will provide some insight into all aspects of the various wind shear conditions that affect flight through the atmosphere.

RECENT PUBLICATIONS:

Sifnificant Events in Low-Level Flow Conditions Hazardous to Aircraft, Margaret B. Alexander and Dennis W. Camp, NASA TM-82522, January 1983.

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APPENDIX A

REPORTS AND PAPERS

1. W. Campbell: "A Conceptual Framework for Using Joint Airport Weather Studies (JAWS) Data for Flight Simulation," submitted as a NASA Technical Publication, March 1983.

2. W. Frost: "Flight in Low-Level Wind Shear," NASA CR-3678, March 1983.

3. S. Akkari and W. Frost: "Analysis of Vibration Induced Error in Turbulence Velocity Measurements from an Aircraft Wind Tip Boom," NASA CR-3571, June 1982.

4. M. Dietenberger: "A Frost Formation Model and Its Validation Under Various Experimental Conditions," NASA CR-3595, August 1982.

5. M. Dietenberger: "Generalized Correlation of the Walter Frost Thermal Conductivity," Int. Journal Heat Mass Transfer, Vol. 26, No. 4, pp. 607-619, 1983.

6. J. Keller and P. Haines: "Detection of CAT Using a Diagnostic Richardson Number Tendency Formulation," Journal of Aircraft, Vol. 19, No. 11, pp. 904-908, Nov.-Dec. 1982.

7. E. Logan, Jr. and S. Lin: "Wakes From Arrays of Buildings," NASA CR-170666, November 1982.

8. S. Lin: "Wind Tunnel Measurements of Three-Dimensional Wakes of Buildings," M. S. Thesis, Arizona State University, May 1982.

9. E. Logan and S. Lin: "Wind Tunnel Measurements of Three-Dimensional Wakes of Buildings," NASA CR-3565, June 1982.

10. W. Frost: "Preliminary Test Results of Electrical Charged Particle Generator for Application to Fog Dispersal," NASA CR-2654, November 1982.

11. W. Frost and K. Huang: "Test Results of Modified Electrical Charged Particle Generator for Application to Fog Dispersal," NASA CR-3674, February 1983.

12. M. Weber, H. Christian, A. Few, and M. Stewart: "A Thundercloud Electric Field Sounding; Charge Distribution and Lightning," Journal of Geophysical Research, 87, p. 7158, August 1982.

13. H. Christian, R. Frost, R. Gillaspy, S. Goodman, O. Vaughan, M. Brook, B. Vonnegut, and R. Orville: "Observations of Optical Lightning Emissions From Above Thunderstorms Using U-2 Aircraft," Bulletin American Meteorological Society, 64, February 1983.

14. D. Camp, W. Frost, E. Gross, J. Sowar, and A. Tobiason: "Fifth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems," 31 March-2 April 1981, Tullahoma, Tennessee," Bulletin AMS, Vol. 63, No. 6, June 1982.

15. W. Frost and D. Camp (Editors): "Proceedings: Sixth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems," NASA CP-2274, April 1983.

16. J. Enders, W. Melvin, W. Frost, and D. Camp: "Summary Proceedings of a Special One-Day Workshop on Wind Shear," to be published as a NASA CP, 1983.

17. "The JAWS Project Operations Summary 1982," NCAR report Boulder, Colorado, February 1983.

18. J. McCarthy, J. Wilson, and T. Fujita: "The Joint Airport Weather Studies Project," Bulletin of American Meteorological Society, Vol. 63, No. 1, pp. 15-22, January 1982.

19. J. McCarthy: "Joint Airport Weather Studies (JAWS) Project," Proceeeing: Sixth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems, pp. 85-95, NASA CP-2274, April 1983.

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APPENDIX B

PRESENTATIONS

1. W. Campbell and W. Frost: "NASA's B-57B Gust Gradient Program," presented at the NASA/MSFC FY-82 Atmospheric Processes Research Review," October 19-21, 1982.

2. W. Campbell, "A Cursory Glance at Results from NASA's B-57B Gust Gradient Program," presented at the Sixth Annual Workshop on Meteorological and Environmental Inputs to Aviation Systems, 1982.

3. D. Camp, W. Campbell, W. Frost, H. Murrow, and W. Painter: "NASA's B-57B Gust Gradient Program" presented at the AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, January 1983 and accepted for publication in Journal of Aircraft.

4. W. Campbell, D. Camp and W. Frost: "An Analysis of Spanwise Gust Gradient Data," presented at the AMS/AIAA 9th Conference on Aerospace and Aeronautical Meteorology at Omaha, Nebraska, June 1983.

5. W. Frost, D. Camp and W. Campbell: "Spanwise Turbulence Modeling," presented at the AMS/AIAA 9th Conference on Aerospace and Aeronautical Meteorology at Omaha, Nebraska.

6. W. Frost, S. Wang, and D. Camp: "The Influence of Turbulence Models on Computer-Simulated Aircraft Landing," presented at the AIAA 20th Aerospace Sciences Meeting, Orlando, Florida, January 1982.

7. J. Keller: "CAT Detection and Forecasting Using Operational NMC Analysis Data," paper presented at 9th Conference on Aerospace and Aeronautical Meteorology of the AMS, June 6-9, 1983, Omaha, Nebraska.

8. S. Lin, E. Logan, Jr., M. Alexander, and D. Camp: "Disturbed Boundary Layer Flow Downstream of Two Laterally Separated Obstacles," presented at IUTAM Symposium, Berlin, Germany, March 1982.

9. H. Christian, L. Lillie, C. Saunders, and J. Hallett: "Laboratory and Field Observations Related to Ice Particle and Aircraft Charging on Convective Storms," International Conference on Lightning and Static Electricity, June 1983.

10. Paper entitled "Airborne Measurement of Atmospheric Backscatter at 10.6 Micrometers," presented at Society of Photo-Optics Instrumentation Engineering Conference, April 1083.

11. J. McCarthy: "JAWS Program," paper presented at AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, January 1983.

12. J. Wilson, J. McCarthy, and T. Fujita: "Application of Doppler Radar to Aviation Operations – JAWS Experiences," paper presented at AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, January 1983.

APPENDIX C

ORGANIZATIONS WHOSE SPONSORED RESEARCH EFFORTS ARE INCLUDED IN THE FY-83 AVIATION SAFETY-RESEARCH REVIEW

FWG ASSOCIATES, INC.

MARSHALL SPACE FLIGHT CENTER, ATMOSPHERIC SCIENCES DIVISION

THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, FIELD OBSERVING FACILITY

THE UNIVERSITY OF CHICAGO

THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE

UNIVERSITIES SPACE RESEARCH ASSOCIATION

UNIVERSITY OF DAYTON RESEARCH INSTITUTE

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Prepared by Atmospheric Sciences Division, Systems Dynamics Laboratory.

16. ABSTRACT

A review of the NASA/MSFC FY-83 Atmospheric Research Review Program, sponsored by the NASA Office of Aeronautics and Space Technology Subsonic Aircraft Office, was held in Huntsville, Alabama, May 24-25, 1983. This report contains the research project summaries, in narrative form, supplied by the individual investigators.

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